University-industry interaction: support to cooperation versus actual cooperation in peripheral regions

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Increasing interaction between university and industry is a common trend of most developed economies. It has received both consent and critique from innovation studies. Some of the debates around the topic are what the objectives of interaction are and whether the attempts to promote it are effective. With a sample from a survey of university professors of a European peripheral region, the Valencian Community, we study the extension of the phenomenon beyond technology-leading countries. We estimate some econometric models that shed some light on the mentioned debates. The results show that certain incentives and instruments of interaction impede that the support to every objective is simultaneous or even compatible and that only selected policies for its promotion have an impact. We recommend a reconsideration of the institutional encouragement experienced during the last two decades.

Keywords: university-industry interaction, peripheral regions

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University-industry interaction: support to their objectives and response to policy initiatives

1. Introduction

When universities incorporated research among their functions in the 19th century, they spontaneously began to generate useful knowledge for society, with an increasing support from industry in countries like US (Etzkowitz and Leydesdorff, 2000). After World War II, the consideration of basic research as the engine of innovation (Bush, 1945) and the fear that an interference in the agendas of researchers would deteriorate the quality of that research made university reduce its contacts with industry. Among other reasons, the productivity crisis of the seventies and a better understanding of the limited resource of firm's innovation to science (Kline and Rosenberg, 1986) explain that the public opinion asks for a more active role of university, ratified by the approval of university managers. Coincident with a surge of commercialisation of science-based technologies, like biotechnology and ICT, seen as examples of successful science by their tangible results, the belief that such an active role must rely on the increase of interaction with industry grew. Unlike the initial spontaneity of interaction, this period in US witnesses its promotion through policies that try to stimulate the development of tangible results. Most European economies followed this example.

Within innovation studies, several approaches have come to justify the necessary interweaving of universities in the economy: Freeman (1987) and Lundvall (1988) an the national systems of innovation, Gibbons et al. (1994) and the new Mode 2 of knowledge production, Etzkowitz and Leydesdorff (1996) and the Triple Helix model, etc. These approaches differ above all in the importance granted to the universities in the innovation process, but they do not question whether to what extent they should interact with firms.

Other voices have been more critical. The economics of science recovers the mertonian ideas that the mechanism of revision by peers can efficiently assign R&D resources (Dasgupta and David, 1994). It also emphasises that the promotion of university-industry interaction (UII) responds to a narrow vision of the benefits of basic research, the less tangible but equally beneficial links with innovation of which are left aside (David et al., 1994). Some of these benefits are useful knowledge, skilled graduates, new instruments and methodology, networks,

ability to solve complex problems, creation of firms (Salter and Martin, 2001), social knowledge and access to unique facilities (Scott et al., 2002).

In a context of opposite opinions on the benefits of UII, it is logical that some debates arise, as the support to its different objectives or its promotion through university and governmental policy measures. The rest of the present work has the following structure: Section 2 details a little more the state-of-the-art on these debates and specifies our research questions. Section 3 explains the methodology through which we address them and the data that we will use to that end. Section 4 shows the results of the applied econometric estimations on the data. Finally, section 5 concludes and suggests lines of future research.

2. The shadows of the support to interaction

2.1. The objectives of university-industry interaction: limits and fears

To our knowledge, the most systematic attempt to study the objectives of UII is the one of Lee (1996), who in 1994 made a survey to around 1000 university professors of 115 American universities. One of the questions dealt with the support that they granted to seven objectives of UII. These were to favour oriented research in the university, to promote patentable inventions, to participate in regional economic development, to intensify the commercialisation of the results of academic research, to stimulate the activities of faculty consulting for the industry, to offer aid for the start-up of new technology-based firms and to stimulate equity investment in firms based on academic research. A majority of the interviewees supported the first five enumerated goals but rejected to support the last two objectives. The author attributed it to the fact that the first five ones represented a pragmatic form of adaptation to the new tendencies of transmission of knowledge, whereas the last two ones imply too narrow commercial relations with the private industry.

The author made an econometric estimation to explain the determinants of the objectives favouring oriented research and commercialisation of the results of academic research and he extended the conclusions to the rest of the objectives of interaction. The results show the greater propensity to support UII of applied sciences, the non-significance of the amount of R&D expenditure, the significant positive impact of institutional encouragement and the significant negative impact of fear to the possible loss of academic freedom.

From our perspective, there are several directions in order to improve the brilliant study of Lee (1996). Firstly, some declared objectives of UII are to obtain additional funds for R&D activities and to adapt teaching programmes, so it would be necessary to include them. Secondly, it is not possible to discard a priori among the determinants of the support to the objectives of UII a series of variables, like personal characteristics or, following Meyer-Krahmer and Schmoch (1998), the incentives (wage, facilitation of professional openings, knowledge exchange, scientific career, etc.) and the instruments (joint research, informal contacts, technological consultancy, practices of alumni, etc.) to interact.

A number of survey studies have approached UII in the case of technology-leading countries (not only Lee, 1996 or Meyer-Krahmer and Schmoch, 1998, but also Etzkowitz, 1998). However, there have been few efforts in catching-up countries, like, according to the Commission of the EC (2001), Italy or Spain. For that reason, it would be convenient to count with a sample of one of these or, at least, of a region of one of them. A first question would be, consequently, if the results of Lee (1996) coincide with those from a region in a catching-up country. A second question would be whether the new included variables provide interesting results. Finally, it is possible to ask ourselves whether the determining factors of the support to the objectives of UII are the same for every objective, as Lee seemed to conclude.

2.2. The effects of the support by government and university managers to university-industry interaction

Another question around the UII debate is if the stimulus to the transference of tangible results from university to industry is actually effective.

Faulkner and Senker (1995) have shown how the emphasis on formal projects does not imply that informal collaborations are not important, and that the former only represents the peak of the iceberg. Better than considering formal and informal interactions like substitutes, we should understand that informal relations usually precede or initiate formal projects.

Rappert et al. (1999), through interviews to a series of spin-off firms, find that these firms think that universities lack entrepreneurial abilities, that they organize their work in a form which is difficult to manage and that they are not interested in developing technology or in properly evaluating it. Informal links do not seem affected by it because firms that maintained them before continue maintaining them, although they sometimes notice that faculty negotiate

in market terms that they do not master, because “the desire to be more commercially relevant then does not necessarily equate with them being commercial per se” (op. cit., p. 882).

Beise and Stahl (1998) extract from a survey to 2300 German firms that firms with publicly supported innovations cite universities as the most important source, before other institutions of more applied or technological content. For this reason, they distinguish between applied orientation of research and successful knowledge transfer.

In this context, it seems appropriate to ask ourselves if the measures that institutions put in practice to favour UII have a significant impact, either from university or from government. We try to answer that question by means of an estimation of the determinants of the cooperation in R&D of faculty with firms, and especially, of the impact of the measures of promotion of university and governmental policy. We will use determinants in common with those the previous section, so we will try to answer whether they are coincident in all cases.

3. Methodology and data

Our intention is to set out and estimate a series of econometric models that shed light on the questions rose in the previous section. Additionally we want to use a sample of faculty of a developed, technologically weak, region that allows us to study the phenomenon from a different perspective of a technology-leading country, which has been the usual one.

In order to estimate the models, we have data on the university professors of the Valencian Community, gathered through a survey made in 2001. The Valencian Community is a region of Spain, a catching-up country, with a per capita GDP on the national average. However, it has a series of technological weaknesses: a reduced level of R&D expenditure (around 0.6% of GDP), mainly on the part of firms (around 25% of total expenditure), a shortage of financial organizations of innovation, and a scarcely developed articulation (Fernandez et al., 2002).

The universe of the survey is the teaching staff of the five public universities of the Valencian Community.. The sample has been 10% of the population, which means 872 individuals. We obtained an answer rate of 44 percent, so the database has 382 observations.

The completion of the survey has allowed us to set up the following model on the support to the objectives of UII, which is an extension of the one of Lee (1996):

$$support_i^o = f(university_i, age_i, gender_i, seniority_i, direction_i, abroad_i, sexenia_i, discipline_i, RDt_i, encouragement_i, incentives_i^c, fear_i^e, instruments_i^s), \quad i = 1,...,N; o = 1,...,O; c = 1,...,C; e = 1,...,E; s = 1,...,S \tag{1}$$

The dependent variable is the support to different objectives of UII, ranged as follows: 0 represents "no or weak support", 1 "some support" and 2 "strong support". It admits the six following alternatives (O=6):

- Orientation: to favour oriented research in the university.
- Development: to participate in the economic development of the region.
- Commercialisation: to intensify the commercialisation of the results of academic research.
- Firms: to favour the creation of firms based on academic research.
- Funds: to obtain additional funds for R&D activities.
- Teaching: to adapt the teaching programmes.

The first four objectives are analogous to those appearing in the model of Lee (1996), whereas the last two ones are new. Here is the list and description of the explanatory variables:

- University: university of the professor. In our sample, we will consider four, which we will measure with dummy variables: *univ1, univ2, univ3, univ4*. We take this last one as a group of reference and it includes in fact the two youngest and smallest universities.
- Age: four blocks of age, numbered from 1 (least aged cohorts) to 4 (most aged cohorts).
- Gender: dummy variable that takes value 1 if the respondent is a man.
- Seniority: teaching scale. There are three scales, which we will measure with their respective dummy variables: *sen1* (full professors), *sen2* (assistant professors) and *sen3* (associate professors). This last one remains as a reference group.
- Direction: dummy variable that takes value 1 if the respondent holds a directive position.
- Abroad: length of the stays abroad, from 0 (the shortest length) to 4 (the largest length).
- Sexenia: number of Spanish six-year term research awards (so-called sexenium), from 0 (less sexenia) to 4 (more sexenia).
- Disciplines: dummy variables for *ens* (exact and natural sciences), *et* (engineering and technology), *ms* (medical sciences), *ssh* (social sciences and humanities) and *as* (agrarian sciences), the reference group.
- RDt: percentage of time of R&D.

- ❖ Encouragement: influence of university policy, with dummies *enc1* (“favourable”), *enc2* (“not influential”) and *enc3* (“discouraging” plus “don’t knows”), the reference group.
- ❖ Incentives: influence of UII on the following aspects, with three possible answers, numbered 1 (“negative”), 2 (“none”) and 3 (“positive”) (C=5):
  - ➢ Wage: wage of the professor.
  - ➢ Openings: professional openings of students and collaborators.
  - ➢ Knowledge: exchange of relevant knowledge.
  - ➢ Subventions: obtaining public resources for R&D projects.
  - ➢ Career: scientific career (obtaining of sexenia).
- ❖ Fear: influence of UII on the following aspect of academic life, numbered -3 (“negative”), -2 (“none”) and -1 (“positive”) (E=1):
  - ➢ Freedom: freedom of election of the subjects of performed R&D.
- ❖ Instruments: preferred activities to interact with firms, each one measured with its own variable, which takes value one if the respondent chose the activity[1]. There are nine (S=9):
  - ➢ Contacts: informal contacts.
  - ➢ Consultancy: advice and technological support.
  - ➢ Practices: practices of students in firms.
  - ➢ Training: lifelong training under companies’ demand.
  - ➢ Contracts: contracted research.
  - ➢ Collaboration: collaborative research.
  - ➢ Licenses: license of patents.
  - ➢ Personnel: interchange of research personnel.
  - ➢ Centres: creation of joint centres.

The second model is the following one:

$$cooperation_i = f(university_i, age_i, gender_i, scale_i, direcction_i, abroad_i, sexenia_i, discipline_i, RDt_i, univpol_i^u, govpol_i^g), i = 1,...,N; u = 1,...,U; g = 1,...,G \quad (2)$$

The dependent variable is the degree cooperation in R&D with firms. We considered three answers, ranging from 0 (“none”) to 2 (“much”). Model 2 includes new explanatory variables:

- ❖ Univpol: importance attributed to the services of the universities to develop UII. We considered four possibilities, from 0 (“none”) to 3 (“high”). They are eight (U=8):

- Aids: information about public aids to fund the relations.
- Partners: aid in the search of interested firms.
- Negotiation: collaboration in the negotiation of contracts.
- Proposals: support to the elaboration of proposals of projects.
- Patents: consultancy for the elaboration and management of patents.
- Start-ups: consultancy for the creation of firms.
- Management: an effective and flexible economic-administrative management.
- Framework: an explicit and adequate normative framework.

❖ Govpol: measures perceived as the most important ones to favour UII on the part of the government[2]. They are twelve, each one measured with a dummy variable (G=12):

- Frame: an adequate legal frame.
- FirmRD: programmes to fund firms' R&D.
- UIRD: programmes to fund joint R&D activities between universities and firms.
- UTRD: programmes to fund R&D between technological institutes and universities.
- ILO: programmes of funds for the activities of industrial liaison offices (ILO).
- Relief: tax relief on firms' R&D.
- TI: funds for technological institutes.
- UI: funds for university institutes or other institutes.
- UnivRD: increase of R&D resources for universities.
- Groups: facilitation of the collaboration among R&D groups.
- Pers: stimulus of the exchange of research personnel between university and industry.
- Technicians: incorporation of technical personnel into firms.

Table 1 offers a perspective on the data through the descriptive statistics of the variables, discarding "don't knows" [3]. The average values show that the most supported objectives are, as in Lee (1996), orientation, development and commercialisation, plus one new, funds. The least supported are the creation of firms, as in Lee (1996), and the adaptation of teaching.

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[1] Respondents could choose up to three activities.
[2] Respondents could choose up to three activities.
[3] We can find a more detailed study in Alto Consejo Consultivo (2001).

4. Results of the estimations

4.1. Model 1: support to the objectives of UII

As the questions on the importance of the objective of UII, that are the dependent variables, admit answers with discrete values between 0 and 2, the adequate technique of estimation of model 1 is an ordered probit. Eliminating the answers of type "don't knows", there remained some less than 200 valid questionnaires. The results appear in Table 2.

In the first place, belonging to older universities influences the support to the objectives of interaction negatively. This influence is significant, mainly, in the case of the oldest universities (*univ2* and *univ3*) and the most supported objectives (orientation, development, funds, and commercialisation).

Secondly, the disciplinary effect is significant to differentiate the importance granted to most of the objectives of UII. In general, faculty in the areas of exact and natural sciences (*ens*) and in social sciences and humanities (*ssh*) are the ones who tend to support the different objectives of interaction in a greater degree. This constitutes a difference with the work of Lee, who found the area of engineering and technology as the most inclined to support them.

Thirdly, the time dedicated to R&D activities (*RDt*) tends to have a negative impact on the support to the objectives of the interaction, but it is not significant. Although our measure of R&D is different to Lee's, this lack of significance is coincident.

In fourth place, the opinion on the endorsement given by universities to interaction (*enc1* and *enc2*) does not have a significant effect. This constitutes another difference with respect to the sample of Lee, where the institutional encouragement was significant indeed.

In fifth place, the fear that UII interferes with academic freedom negatively influences the support, significantly for some of the most valued objectives (orientation, development) as much as for the least valued one (teaching). It is a result in which we totally agree with Lee.

The new variables used to extend Lee's model allow us to derive additional results. To begin with, none of the personal characteristics that we considered is significant.[4]

Secondly, the incentives of interaction exert a diverse influence with regard to sign, significance and objective. The possibilities of improving the wage or the career perspectives

[4] The only exceptions are a weakly significant greater support of assistant professors, *sc2*, to the objective of commercialisation and a smaller support of professors with longer stays abroad to the acquisition of funds.

do not significantly influence the support to the objectives of interaction. Neither does, in general, the improvement of the professional openings, except, negatively, in the case of the acquisition of funds. The exchange of relevant knowledge and the acquisition of public grants for R&D are more important. Knowledge exchange acquires a positive sign to favour oriented research that becomes negative in the case of the participation in the economic development of the region. Obtaining public grants has a significant positive effect on the support to the objectives of funds but not of commercialisation. When one supports the objective of obtaining additional funds of R&D, it does not necessarily mean funds financed by firms.

Finally, the instruments of interaction also exert a diverse influence. Among the most supported objectives, only contracts satisfy all of them. For the rest of instruments, we may notice a dual pattern. Orientation and development depend on more and different instruments than funds and commercialisation. This may indicate that we should consider them as two types of objectives, perhaps according to their scope. The former would have higher social scope, while the latter would have higher individual scope. On the former, contacts, consultancy, practices, licenses and personnel (and centres in the case of development) have a positive, significant influence. On the latter, just training is in this case. This is relevant if we think that no instrument will foster simultaneous support for every objective. Specially, if instruments that allow supporting social objectives do not allow supporting individual ones, respondents will be less prone to use them.

Consultancy is the only instrument that fosters support to the adaptation of teaching, the less valued objective. The reason may indicate that professors who prefer consultancy to interact acquire knowledge about local firms and they are able to transmit these firms' needs to students. The risk is whether university teaching should not rely on higher-level knowledge.

In the model of creation of firms, we reject the null hypothesis that the coefficients of the explanatory variables are jointly equal to zero only at 10% level of significance. Hence, our knowledge regarding the support to this objective is rather limited.[5]

4.2. Model 2: response to measures of promotion of UII

In the case of model 2, the dependent variable is again categorical, so the appropriate technique of estimation is the ordered probit model. The estimation results are in Table 3. The

[5] That is why we prefer not to give comments on the effects of instruments on it.

first one is the full model with all the explanatory variables. The second column is the reduced form, taking into account variables with some predictive power. We prefer the second specification after comparing the Bayesian Information Criteria (BIC).

It is possible to observe that the respondent's university does not have a significant impact, despite having it on the support to the objectives of interaction. Actually, we can drop this variable in the reduced model.

The opposite occurs with personal characteristics. Although they did not have an influence on the objectives of UII, some of them do have it on actual cooperation. It is the case of gender and (weakly) age. The former is positive and it may indicate a field in which females have not integrated. The positive influence of age may be because younger professors have to devote more time to activities other than R&D.

The disciplinary effect is scarce, only weakly significant in the case of social sciences and humanities, but notice that the only discipline with a positive sign is engineering and technology, that is to say, it is the one that cooperates more with firms, which is logical given the proximity of its R&D to the firm’s needs. This picture is symmetrical to that of the objectives of UII. Disciplines that give more support to them are those that actually cooperate less. The opposite is also true. That may mean that the former are less conscious of the scope of UII and that in fact a snobbish effect pushes them to join a general state of opinion. Perhaps it is an idiosyncrasy of peripheral regions, where researchers in these disciplines experience more pressure to interact, and the reaction is to interiorise the objectives of the interaction even more than in engineering and technologies, although they do not reach their degree of effective cooperation. On the other hand, the phenomenon may be reflecting a certain fatigue of engineering and technologies, disciplines that would appreciate to devote fewer resources to interact.

The time dedicated to R&D influences cooperation positively, perhaps because it makes it possible to offer more results. This is another difference compared to the support to the objectives of UII, on which that variable does not matter.

The institutional encouragement, nevertheless, is innocuous on both actual cooperation and the support to its objectives. We can drop this variable in the reduced model.

Among university policy measures, only one out of eight, the information on public aids to fund the relations, the most valued option, has a significant impact, which is positive. Hence, university policies have to be very accepted and general in scope to promote interaction.

Among governmental measures, three out of twelve have a strongly significant impact, always positive. The first is funds for joint R&D activities between universities and firms, the most valued option again, and the logical complement of the most significant university policy measure. The others are the facilitation of the collaboration among R&D groups and the incorporation of technical personnel into firms, despite being among the less valued options. .They may reflect that indirect measures that increase multidisciplinarity and capacity of absorption are crucial to cooperate, although the bulk of professors appreciate measures that are more direct (see Table 1). A fourth measure, an adequate legal frame, becomes significant in the reduced model, but just weakly.

5. Conclusions

A European peripheral region like the Valencian Community, an example of economic development with technological weaknesses, has internalised the same objectives of UII that seem valid in technology-leading countries and it establishes similar limits. The support to these objectives is a social phenomenon, sensitive to institutional influences (not through direct support but through the creation of a state of opinion), incentives, fears and instruments. On the contrary, actual cooperation with firms, that is an act and not an opinion, is a more individual phenomenon, on which age, gender and dedication to R&D have an influence.

Like such a social phenomenon, the support to the interaction takes the form of a process in which it is difficult to address simultaneously all the individuals towards all the admissible objectives, even towards those that receive a greater endorsement by faculty. This spawns scarcely predictable dynamics at the time of creating a state of favourable opinion towards interaction. First, the fact that those who value the knowledge exchange to orient research towards innovation or even to adapt teaching, do not believe that it contributes to regional development. Second, the fact that to cooperate with firms serves to obtain additional funds by means of a public award, putting into question the idea that the cooperation reduces the load on the public budget and reinforcing the cumulative prestige of the groups of excellence. Third, the fact that, except in the case of contracts, the dichotomy between the (numerous)

instruments leading to the support of more social objectives and the (few) instruments leading to the support of more individual objectives may impede the simultaneous support to every objective. Fourth, the fact that consultancy is also seen as a means to adapt teaching may put into risk the transmission of less tangible but most valuable knowledge.

Still from the social perspective, it is necessary to consider the disciplinary effect on interaction, that is dependent on the geographic context, among other reasons because the specialization in science-based sectors and the absorptive capacity of local firms are greater in a technology-leading country that in a peripheral region. It leads to a situation in which faculty of exact and natural sciences and social sciences and humanities, where there is less cooperation in R&D with firms, support in an even more exacerbate form the objectives of interaction than their colleagues in engineering and technology. A situation of social snobbishness may cloud the vision of better alternatives, like the maintenance of a critical level of basic research and a smaller investment in efforts to promote interaction.

Nevertheless, a favourable state of opinion may arise because there exist pure teaching and scientific incentives (in fact the most valued ones) to cooperate, like knowledge exchange, public grants for R&D and the opening of the labour world for graduates. Throughout the last decades, the conditions have been set for UII to take place, and it is difficult that such an evolutionary process reverts. On the other hand, it could happen that the process, blinded in his forward march, stagnated without correcting the disadvantages.

For all these reasons, we recommend that the promotion of the support to interaction slows down, with the aim that the phenomenon stands spontaneously, and we should study if science and technology policies to counterweight the negative effects of interaction can be effective. In any case, policies for its promotion compel a combination of public grants from government to fund joint R&D activities with complementary aid from university to search and select these grants. In addition, policies may require discarding a wide range of short-term measures that, although popular and direct, are less efficient to promote interaction than longer-term, less popular and indirect one, e.g. collaboration among R&D groups and the incorporation of technical personnel into firms.

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Tables

Table 1 Descriptive statistics of the sample

Variable	Sub variable	Mean	Std. Dev.	Minimum	Maximum	Observations
Objectives	Orientation	1.51	0.65	0	2	371
	Development	1.35	0.71	0	2	369
	Commercialisation	1.15	0.76	0	2	366
	Firms	0.96	0.81	0	2	367
	Funds	1.36	0.71	0	2	368
	Teaching	0.80	0.77	0	2	371
University	Univ1	0.19	0.39	0	1	382
	Univ2	0.29	0.45	0	1	382
	Univ3	0.33	0.47	0	1	382
Age		2.75	0.86	1	4	378
Gender		0.72	0.45	0	1	380
Seniority	Sen1	0.46	0.50	0	1	380
	Sen2	0.32	0.47	0	1	380
Direction		0.18	0.39	0	1	376
Abroad		1.39	1.36	0	4	373
Sexenia		0.77	1.15	0	4	365
Discipline	Ens	0.22	0.41	0	1	376
	It	0.32	0.47	0	1	376
	Ms	0.09	0.28	0	1	376
	Ssh	0.32	0.47	0	1	376
RDt		30.61	18.44	0	90	376
Encouragement	Enc1	0.55	0.50	0	1	378
	Enc2	0.14	0.34	0	1	378
Incentives	Wage	2.52	0.61	1	3	312
	Openings	2.85	0.46	1	3	364
	Knowledge	2.75	0.54	1	3	356
	Subventions	2.78	0.52	1	3	344
	Career	2.22	0.72	1	3	299
Fear	Freedom	-2.06	0.81	-3	-1	306
Instruments	Contacts	0.09	0.29	0	1	360
	Consultancy	0.54	0.50	0	1	360
	Practices	0.38	0.49	0	1	360
	Training	0.19	0.39	0	1	360
	Contracts	0.54	0.50	0	1	360
	Collaboration	0.58	0.49	0	1	360
	Licenses	0.05	0.22	0	1	360
	Personnel	0.19	0.39	0	1	360
	Centres	0.21	0.41	0	1	360
Cooperation		0.75	0.77	0	2	373
Univpol	Aids	2.62	0.60	0	3	355
	Partners	2.62	0.64	0	3	351
	Negotiation	2.28	0.77	0	3	342
	Proposals	2.15	0.81	0	3	347
	Patents	2.29	0.77	0	3	309
	Start-ups	2.04	0.88	0	3	315
	Management	2.57	0.63	0	3	341
	Framework	2.49	0.68	0	3	333
Govpol	Frame	0.28	0.45	0	1	355
	FirmRD	0.15	0.35	0	1	355
	UIRD	0.58	0.49	0	1	355
	UTRD	0.11	0.31	0	1	355
	ILO	0.06	0.24	0	1	355
	Relief	0.34	0.47	0	1	355
	TI	0.07	0.26	0	1	355
	UI	0.22	0.41	0	1	355
	UnivRD	0.42	0.49	0	1	355
	Groups	0.10	0.30	0	1	355
	Pers	0.26	0.44	0	1	355
	Technicians	0.15	0.36	0	1	355

Table 2 Ordered probit estimation of the support granted to different possible objectives of university-industry interaction

Variable	Sub-variable	Orientation	Development	Funds	Commercialisation	Firms	Teaching
Constant		-0.30 (1.18)	-1.15 (1.18)	-1.62 (1.18)	-1.44 (1.11)	-3.91 (1.21) ***	-4.78(1.33) ***
University	Univ1	-0.50 (0.38)	-0.5 (0.34)	-0.51 (0.35)	-0.56 (0.33) *	-0.21 (0.31)	-0.34 (0.33)
	Univ2	-0.52 (0.37)	-0.68 (0.33) **	-1.02 (0.35) ***	-0.83 (0.32) **	-0.11 (0.31)	-0.31 (0.32)
	Univ3	-1.02 (0.35) ***	-0.9 (0.32) ***	-1.05 (0.33) ***	-1.01 (0.31) ***	-0.45 (0.3)	-0.07 (0.3)
Age		-0.14 (0.16)	-0.17 (0.15)	0.14 (0.15)	-0.02 (0.14)	-0.1 (0.14)	0.06 (0.14)
Gender		-0.08 (0.25)	0.11 (0.23)	-0.09 (0.24)	0.28 (0.23)	0.23 (0.24)	-0.05 (0.24)
Seniority	Sen1	0.51 (0.38)	0.36 (0.36)	-0.01 (0.36)	0.25 (0.35)	0.28 (0.35)	-0.12 (0.36)
	Sen2	0.28 (0.34)	0.45 (0.32)	0.21 (0.32)	0.55 (0.31) *	0.38 (0.31)	-0.03 (0.32)
Direction		0.26 (0.28)	0.12 (0.26)	0.28 (0.26)	0.15 (0.25)	0.05 (0.25)	-0.1 (0.26)
Abroad		0.03 (0.09)	-0.06 (0.08)	-0.15 (0.09) *	-0.09 (0.08)	-0.05 (0.08)	-0.01 (0.09)
Sexenia		-0.07 (0.11)	0.02 (0.11)	0.13 (0.1)	-0.05 (0.1)	0.02 (0.1)	-0.07 (0.11)
Discipline	Ens	1.40 (0.5) ***	0.77 (0.46) *	0.73 (0.49)	0.62 (0.47)	1.88 (0.52) ***	0.68 (0.52)
	It	0.76 (0.45) *	0.67 (0.43)	0.46 (0.45)	0.41 (0.43)	1.32 (0.49) ***	0.92 (0.49) *
	Ms	0.36 (0.58)	0.56 (0.55)	0.84 (0.59)	0.49 (0.56)	1.35 (0.61) **	0.99 (0.61)
	Ssh	0.81 (0.51)	1.00 (0.48) **	0.57 (0.51)	0.83 (0.48) *	1.78 (0.53) ***	1.18 (0.53) **
RDt		-0.65 (0.68)	-0.49 (0.67)	-0.32 (0.66)	0.88 (0.64)	-0.01 (0.64)	-0.03 (0.65)
Encouragement	Enc1	-0.01 (0.25)	0.26 (0.24)	-0.25 (0.25)	0.02 (0.24)	-0.33 (0.24)	-0.45 (0.25) *
	Enc2	-0.05 (0.3)	0.13 (0.29)	0.13 (0.3)	-0.11 (0.28)	-0.04 (0.29)	0.19 (0.28)
Incentives	Wage	-0.24 (0.18)	-0.22 (0.17)	-0.07 (0.17)	-0.22 (0.17)	0 (0.17)	-0.11 (0.18)
	Openings	-0.29 (0.28)	0.27 (0.27)	-0.6 (0.28) **	-0.09 (0.26)	-0.01 (0.26)	0.3 (0.29)
	Knowledge	0.41 (0.23) *	-0.43 (0.22) *	0.02 (0.22)	-0.01 (0.21)	-0.1 (0.21)	0.28 (0.22)
	Subventions	-0.12 (0.23)	-0.09 (0.22)	0.93 (0.24) ***	0.34 (0.22)	0.39 (0.23) *	0.34 (0.24)
	Career	0.02 (0.17)	0.11 (0.16)	0.08 (0.16)	0.17 (0.15)	-0.03 (0.15)	0.03 (0.16)
Fear	Freedom	-0.41 (0.14) ***	-0.3 (0.13) **	-0.14 (0.13)	-0.06 (0.13)	-0.02 (0.12)	-0.61 (0.14) ***
Instruments	Contacts	1.10 (0.44) **	0.98 (0.42) **	0.49 (0.42)	0.28 (0.39)	0.59 (0.4)	0 (0.42)
	Consultancy	0.75 (0.29) ***	1.22 (0.3) ***	0.39 (0.29)	0.26 (0.27)	0.7 (0.3) **	0.65 (0.31) **
	Practices	0.61 (0.31) **	0.99 (0.32) ***	0.69 (0.31)	0.56 (0.3)	1.02 (0.33) ***	0.67 (0.32)
	Training	0.43 (0.33)	0.36 (0.33)	0.56 (0.33) *	0.62 (0.31) **	0.55 (0.33) *	0.19 (0.34)
	Contracts	0.86 (0.29) ***	1.19 (0.3) ***	1.08 (0.29) ***	0.83 (0.28) ***	1.12 (0.31) ***	0.44 (0.3)
	Collaboration	0.25 (0.28)	0.52 (0.29) *	0.72 (0.29) **	0.35 (0.27)	0.7 (0.3) **	-0.1 (0.3)
	Licenses	0.82 (0.48) *	1.44 (0.48) ***	-0.43 (0.45)	0.63 (0.44)	0.56 (0.47)	0.12 (0.46)
	Personnel	0.68 (0.33) **	0.88 (0.33) ***	0.19 (0.32)	0.61 (0.31) *	0.89 (0.33) ***	0.01 (0.33)
	Centres	0.45 (0.32)	1.23 (0.34) ***	0.32 (0.33)	0.48 (0.31)	0.8 (0.33) **	0.09 (0.34)
μ_1		1.41 (0.16) ***	1.46 (0.14) ***	1.42 (0.14) ***	1.44 (0.13) ***	1.07 (0.11) ***	1.11 (0.12) ***
Number of observations		195	193	193	193	192	194
Log-likelihood Function *log*L		-142.63	-162.80	-161.35	-177.58	-187.58	-172.33
Restricted Log-likelihood		-172.13	-193.92	-194.56	-201.63	-210.49	-206.57
χ^2-test		59.00 ***	62.24 ***	66.43 ***	48.09 **	45.83 *	68.50 ***
Degrees of Freedom		32	32	32	32	32	32

* Significant at 10%. ** Significant at 5%. *** Significant at 1%.

Table 3 Ordered probit estimation of the level of cooperation with firms in R&D activities

Variable	Sub variable	Cooperation (full model)	Cooperation (reduced model)
Constant		-4.26 (0.94) ***	-3.86 (0.91) ***
University	Univ1	-0.19 (0.28)	
	Univ2	0.22 (0.29)	
	Univ3	-0.32 (0.28)	
Age		0.18 (0.13)	0.22 (0.13) *
Gender		0.89 (0.23) ***	0.84 (0.22) ***
Seniority	Sen1	0.37 (0.29)	0.29 (0.28)
	Sen2	-0.04 (0.25)	-0.03 (0.25)
Direction		0.1 (0.24)	0.1 (0.22)
Abroad		0.12 (0.07)	0.12 (0.07)
Sexenia		0.04 (0.1)	0.02 (0.1)
Discipline	Ens	-0.31 (0.46)	-0.67 (0.42)
	It	0.48 (0.41)	0.4 (0.4)
	Ms	-0.33 (0.51)	-0.7 (0.47)
	Ssh	-0.44 (0.46)	-0.79 (0.42) *
RDt		1.82 (0.53) ***	1.78 (0.52) ***
Encouragement	Enc1	0.03 (0.23)	
	Enc2	0.48 (0.28) *	
Univpol	Aids	0.45 (0.2) **	0.41 (0.19) **
	Partners	-0.31 (0.2)	-0.21 (0.19)
	Negotiation	-0.05 (0.16)	-0.06 (0.16)
	Proposals	0.06 (0.16)	0.04 (0.15)
	Patents	0.21 (0.18)	0.18 (0.17)
	Start-ups	-0.08 (0.13)	-0.05 (0.13)
	Management	0.23 (0.18)	0.19 (0.18)
	Framework	0.06 (0.17)	0 (0.17)
Govpol	Frame	0.4 (0.27)	0.42 (0.25) *
	FirmRD	0.44 (0.29)	0.44 (0.28)
	UIRD	0.71 (0.25) ***	0.7 (0.24) ***
	UTRD	0.1 (0.31)	0.12 (0.31)
	ILO	0.39 (0.42)	0.22 (0.42)
	Relief	0.12 (0.24)	0.15 (0.24)
	TI	-0.19 (0.38)	-0.13 (0.37)
	UI	0.32 (0.28)	0.3 (0.28)
	UnivRD	0.15 (0.24)	0.16 (0.23)
	Groups	0.68 (0.32) **	0.7 (0.32) **
	Pers	0.28 (0.25)	0.28 (0.24)
	Technicians	0.72 (0.27) ***	0.67 (0.27) **
μ_1		1.54 (0.14) ***	1.5 (0.14) ***
Number of observations		226	226
Log-likelihood Function logL		-179.54	-182.92
Restricted Log-likelihood		-236.75	-236.75
χ^2-test		114.43 ***	107.66 ***
Degrees of Freedom		37	32

* Significant at 10%. ** Significant at 5%. *** Significant at 1%.